

# $^3\text{He}$ polarization

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## Requirements

- $P_3 \approx 1$ 
  - $\delta f \propto 1/P_3$        $P_3, P_n \approx 1$
  - $\delta f \propto 1/P_3^2$        $P_n \approx 0$
  - $\delta f \propto 1/P_3^m$        $P_3, P_n \neq 1$
- $\sim 10^{12} \ ^3\text{He}/\text{cm}^3$       ( $\chi_3 \sim 10^{-10}$ )  
 $\longrightarrow 10^{16}$  in 8 L      (collect in 1000 s)

## Quadrupole state selector

- $P_3 > 0.99$  initially
- $I_0 > 10^{14}/\text{s}$

# Transport of $\uparrow^3\text{He}$

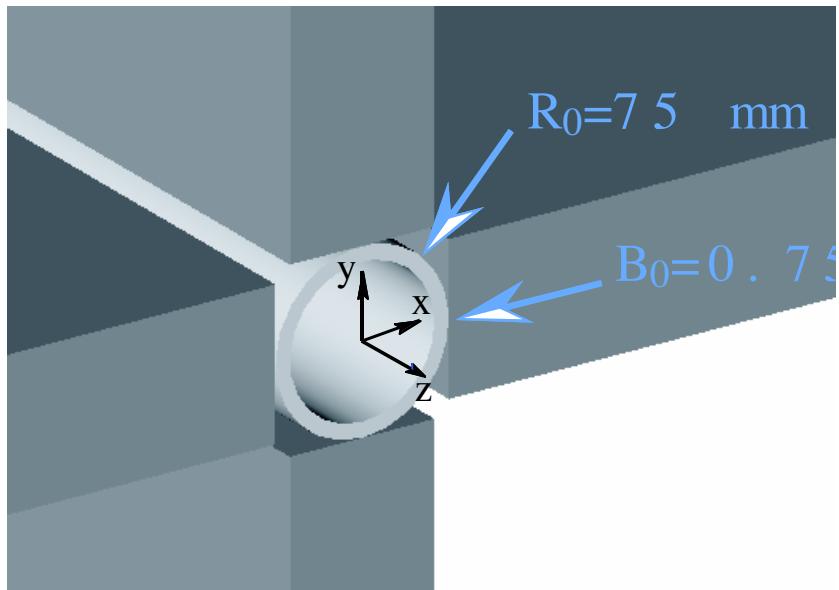
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## Magnetic field issues

- Gradient at quadrupole exit
- Reduce field before experimental volume
- Bent  ${}^3\text{He}$  guide (horizontal polarizer)
- Higher  ${}^3\text{He}$  temperatures (300 K) and field gradients

# Gradient after quadrupole

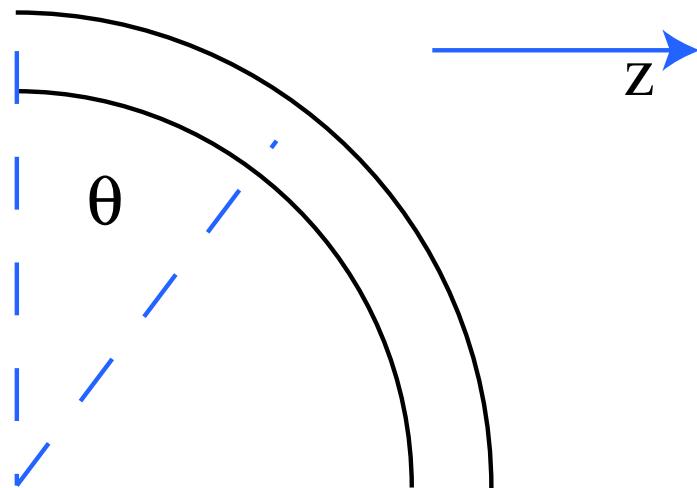
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- $|\frac{dB/dt}{B}| \ll \mu B; \frac{dB}{dt} = v_z \frac{dB}{dz}$
- $v_z = 80 \text{ m/s}$  ( $T = 1 \text{ K}$ )
- $B_z(z) \simeq \frac{1}{30} B_0 \frac{R_0^4}{z^4}$  on axis
  - applied  $B \gg 400 \text{ mG}$
- $B_y(z) \simeq \frac{1}{3} B_0 e^{-z/z_0}$  for  $y = R_0/2$  and  $z_0 = 3.3 \text{ mm}$ 
  - applied  $B \gg 1200 \text{ mG}$

## Bent ${}^3\text{He}$ guide

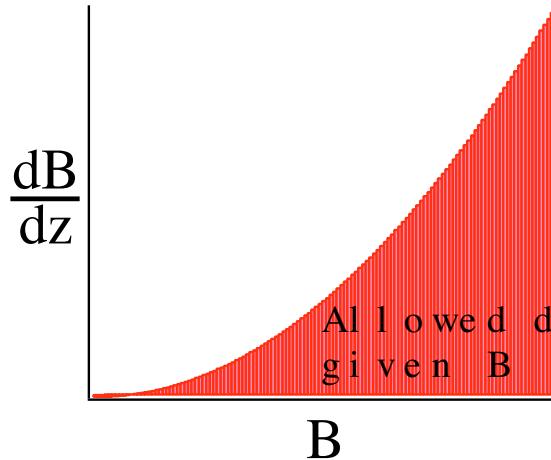
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- $B_z = B_r \cos(\theta)$  and  $v_z = v \cos(\theta)$
- $|\frac{dB}{dz}| = B_0 \frac{z}{R^2} / \cos(\theta)$
- $B_0 \gg \frac{z}{R^2} \frac{v}{\mu} \gg \frac{v}{R\mu}$ 
  - $B_0 \cdot R \gg 100 \text{ mG}\cdot\text{m}$  at 300 K
  - assuming  $|B| = B_0$  everywhere

# Reducing applied B field

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- $|\frac{dB/dt}{B}| \ll \mu B; \frac{dB}{dt} = v_z \frac{dB}{dz}$
- $\frac{dB}{dz} = -\frac{1}{3v_z}\mu B^2$
- $B = \frac{B_0}{1+z/z_0}; z_0 = \frac{3v_z}{\mu B_0}$ 
  - $z_0 = 3.3 \text{ mm}$  for  $v_z = 80 \text{ m/s}$  ( $T = 1 \text{ K}$ )
  - $3600 \text{ mG} \longrightarrow 10 \text{ mG}$  in  $1.2 \text{ m}$   
( $20 \text{ m}$  for  $T = 300 \text{ K}$ )

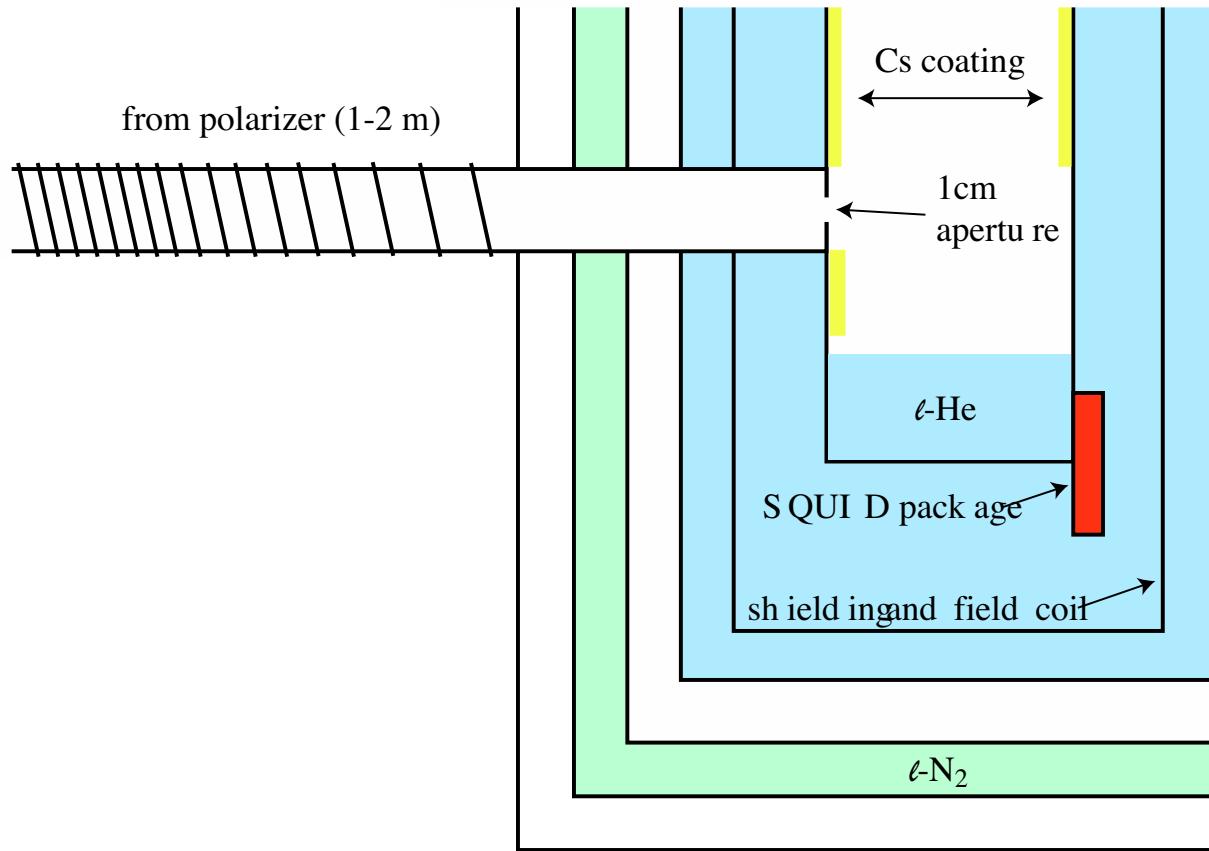


Los Alamos

Physics

# Conceptual Design

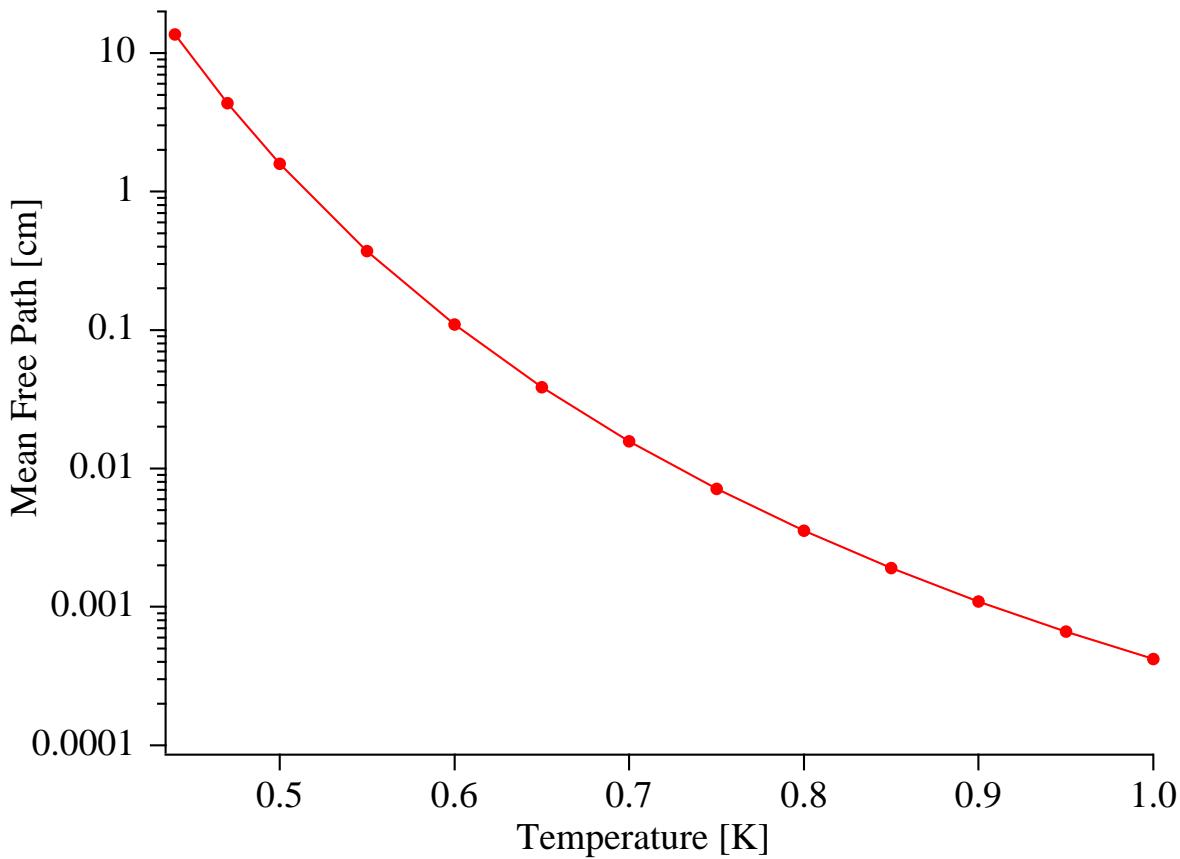
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- Beam divergence  $< 1^\circ$
- First surface of impingement is cold
  - bigger  $\frac{dB}{dz}$  is tolerated

# He Mean Free Path

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- $T < 400 \text{ K}$  is required